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ABSTRACT

In mathematics, Canadian students perform poorly, and enrollment in Canadian postsecondary institutions is low, particularly for women. Clearly, there is a need to understand the personal and social factors that influence mathematics achievement and academic choices. A. Bandura's self-efficacy theory (1977, 1982) implies that academic choices are based on expectations of personal efficacy. In this study, differences distinguishing students who did and those who did not plan to pursue math-related postsecondary programs, and those distinguishing males and females with respect to math achievement, learning and instructional processes, and internal motivation variables were assessed. A total of 191 12th-grade algebra students (99 males and 92 females) enrolled in three Canadian schools were administered a mathematics test, three rating scales, and a questionnaire. Multivariate analysis of variance showed that the effects of gender and intention to pursue a program were significant, but interaction effects were not. These findings suggest that, for both male and female students, instructional approaches that increase student motivation for and enjoyment of mathematics are most likely to increase participation and achievement in mathematics. More emphasis should be placed on the usefulness and relevance of math to everyday life. Five data tables are included. (Author/TJH)

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Mathematical Competence:
Personal and Social Influences

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Abstract

In mathematics, our students perform poorly and enrollment in our post-secondary institutions is low. This is particularly so for women. Clearly, there is a need to understand what personal and social factors influence mathematics achievement and academic choices. Bandura's self-efficacy theory (1977, 1982) implies that academic choices are based on expectations of personal efficacy. Several researchers have reported relationships between sex-related differences in self-efficacy and various career choices. In this study, the hypotheses of no differences between (1) students who planned to pursue math-related post-secondary programs and those who did not, and (2) males and females with respect to math achievement, learning and instructional processes, and internal motivational variables were tested. A total of 225 Algebra 30 (a grade 12 course) students in three schools wrote a mathematics test, and completed three rating scales and a questionnaire. Multivariate analyses of variance showed that the main effects of (1) intention to pursue program and (2) sex were significant at $p < .05$, but the interaction effects

were not. Implications for curricular and instructional guidance are discussed.

Mathematical Competence: Personal and Social Influences

Our educated young people may have inadequate mathematical skills to meet the demands of a technological society. First, North American students do not perform well in mathematics (International Assessment of Educational Progress, 1988). Second, mathematics has been described as the "critical filter" in the pursuit of scientific and technical careers (Sells, 1980), but participation in math-related academic programs at post-secondary institutions is low; females in particular are underrepresented in math-related programs (Vetter, 1981). Early decisions of young people not to study academic mathematics in high school might be restricting their academic and career choices available.

If one accepts the premise of no genetic differences in intellectual development in people of different countries, one must ask what social contextual and personal motivational factors may have influenced students' mathematics achievement and academic choice.

The need for understanding the determinants of mathematics enrollment decisions in post-secondary

education is urgent (Paulos, 1988). The present study was designed to address this need. In addition, whether these factors influence male and female students differently was examined. We hope that such understanding would offer practical curricular and instructional guidance for educators.

Mathematics Achievement, Participation, and Academic Choice

Previous research (e.g., Lantz & Smith, 1981) suggests that mathematics achievement, participation, and academic choice are interrelated. Math participation was associated with subjective value placed on math, liking math, and confidence in math. When math preparation was controlled for, similar affective and motivational variables were the most important predictors of mathematics achievement (Fennema & Sherman, 1977).

Similarly, in a path analysis, Ethington and Wolfle (1988) found that mathematics attitude and locus of control had significant direct effects on math achievement, and indirect effects on math achievement and selection of quantitative field of study mediated through number of courses taken.

That males generally excel in mathematics is well-documented (Backman, 1972; Ernest, 1976; Fennema, 1974; Fox, Brody, & Tobin, 1980; National Assessment of Educational Progress, 1988). During high school years, males generally outperform females (Randhawa, 1988; Randhawa & Hunt, 1987).

Such sex differences in math achievement have been explained on the basis of underlying ability (Benhow & Stanley, 1980; 1981; 1983), differential course-taking (Sherman & Fennema, 1977), socialization in affective and motivational factors such as attitudes (Ethington & Wolfle, 1988; Fennema & Sherman, 1977), and acquisition of autonomous learning behaviors (Fennema & Peterson, 1985).

Males seem to have a more positive attitude towards mathematics than females. By high school, males are more confident than females (Eccles, 1984; Fennema & Sherman, 1977). Females consistently underestimate their math ability (Dossey, Mullis, Lindquist, & Chambers, 1988; Lantz & Smith, 1981). The greater confidence of males in math may well reflect the greater representation of males in careers in sciences and technology (Linn & Hyde, 1989).

The Self-efficacy Approach to Academic Choice Decision

An important theoretical perspective for academic decisions or choices is the self-efficacy expectations (Bandura, 1977, 1982). This theory postulates that behavior and behavior change are mediated primarily by expectations of personal efficacy, i.e., expectations or beliefs that one can successfully perform a given behavior.

Hackett and Betz (1981) proposed a self-efficacy approach to women's career choice. Through differential socialization experiences, females have developed lower self-efficacy in most areas, particularly in nontraditional occupations and thus perceive a limited variety of career options.

Furthermore, Betz and Hackett (1983) related self-efficacy expectations with several affective and motivational variables found to be important in Fennema and Sherman's work. They reported, as hypothesized, lower math self-efficacy expectations in women than in men. Males indicated more positive attitudes toward math, greater confidence in their math ability, and a greater tendency to view math as useful. In addition, students reporting stronger math self-efficacy

expectations, more years of high school math, and lower levels of math anxiety were more likely to have selected science-based college majors.

In addition to internal motivational variables, social contextual variables may be important. As Fennema and Peterson (1985) proposed, any differential classroom experiences should influence the development of one's internal motivational beliefs and/or directly influence the participation of autonomous learning behaviors, which in turn affect mathematics achievement. Little attention has been given, however, to examining how instructional and learning processes relate to mathematics achievement and academic choice and if there are any sex differences.

Learning and Teaching Processes

There is substantial evidence of behavioral differences in the classroom between boys and girls and of sex differences in student-teacher interactions [see Lockheed & Klein (1985) and Fennema & Peterson (1985) for reviews]. Boys tend to be much more independent than girls (Maccoby & Jacklin, 1974). They are not afraid to talk and to ask questions in the classroom whereas girls are more passive (Stake & Katz, 1982).

Teachers seem to initiate more contact and interact more with male students than with female students, especially high confidence and high achieving boys (Fennema, 1983). Boys receive more discipline as well as praise (Maccoby & Jacklin, 1974). Teachers also accept mistakes more from boys than from girls and criticize girls more on their academic work (Dweck, Davidson, Nelson, & Enna, 1978).

These sex-related student-teacher interactions may primarily be precipitated by students' behaviors (Lockheed & Klein, 1985). Teachers may pay more attention to male students who aggressively seek information; as a result, teachers may provide them additional feedback, encouragement and opportunities for practice (Dweck, 1986, cited in Linn & Hyde, 1989).

Despite these differences in student-teacher interactions, Sherman and Fennema (1977) reported little evidence that females more than males perceived their teachers as any less positive toward them as learners of math.

In the present study, the relationships between math participation, math achievement, and academic choice, and a number of personal motivational variables

(e.g., self-esteem and self-efficacy) and social contextual variables (e.g., learning style and perception of teacher) were examined. Specifically, the following hypotheses were tested:

(1) There will be no differences between grade 12 students who plan to pursue mathmatics-related post-secondary academic programs and those who do not in

(i) components of a common high school mathematics achievement test;

(ii) retrospective recall of learning and instructional processes; and

(iii) personal and motivational constructs.

(2) There will be no differences between male and female students in the same three aspects identified in number (1) above.

Method

Sample

The sample consisted of 225 high school students enrolled in nine Algebra 30, an academic grade 12 course, classes in three high schools in a medium-size city in mid-western Canada. One hundred and ninety-one (99 male and 92 female) students provided complete sets of data.

Instruments

A mathematics achievement test, three rating sca and one questionnaire were used in this study.

Mathematics Achievement Test. The 40-item test developed for this study to measure algebra achieveme of Grade 12 students. Its preliminary forms were pil tested on 135 students. In the final form, each item was categorized along two dimensions, the cognitive level dimension and the content area dimension. The cognitive level categories, arranged in ascending ord of cognitive complexity, were: (1) identification of concepts, (2) computation, (3) comprehension of concepts, (4) application and problem solving (Begle Wilson, 1970; Bloom, 1956). The content areas were: number and sets of numbers, (2) powers and radicals, polynomials, (4) solving equations and inequalities, systems of equations, and (6) functions, graphs, and variations.

Mathematics Survey I. The Mathematics Survey I (modified from Ethington & Wolfe, 1988) assessed students' self concept, locus of control, attitude toward mathematics, sex-role orientation, and family orientation. Students indicated whether they strongl

agreed, agreed, disagreed, or strongly disagreed with each of the 23 statements.

Mathematics Self-efficacy Scale. The Mathematics Self-efficacy Scale (modified from Betz & Hackett, 1983) measured students' self-efficacy in performing everyday math tasks, solving math academic problems, and completing mathematics-related high school courses. Students indicated their confidence on a ten-point scale, ranging from "No confidence at all" to "Complete confidence".

Mathematics Survey II. The Mathematics Survey II was adapted from a previous study on university students (Randhawa, Beamer, & Yuzik, 1989). Students provided demographic information, data on their learning and instructional processes, and their personal, parents' and teachers' sex stereotypical biases.

Mathematics Attitude Inventory. The Mathematics Attitude Inventory was developed by the Minnesota Research and Evaluation Project Team (1972). It measured students' attitude toward mathematics with respect to perception of their teachers, anxiety, value in society, perception of their abilities, enjoyment, and motivation. Students indicated whether they

strongly agreed, agreed, disagreed, or strongly disagreed with each of the 48 statements.

Procedure

Students who were willing to participate provided data in three regular class periods in late 1989. In the first session, students were given 50 minutes to write the Mathematics Achievement Test. They were allowed to use calculators. During the second session, students completed the Mathematics Survey I and the Mathematics Self-efficacy Scale in about 45 minutes. In the last session, students completed the Mathematics Survey II and the Mathematics Attitude Inventory in about 40 minutes.

Analysis

Reliability of the Instruments

The responses to negatively-worded items in the attitude and motivation instruments were coded in the reverse order. The item scores were added up to obtain the total score or the component score. Generally, higher scores indicate more positive dispositions than do lower scores.

The internal consistency reliability estimate of each scale was computed. After two items with low

item-total correlations and an obsolete item had been discarded from Mathematics Survey I and Mathematics Self-efficacy Scale, respectively, the internal consistency of all the scales and all except two subscales was judged to be adequate. The two with low internal consistency had alphas of .36 and .42. The range for the rest was .67 to .92 (see Table 1).

Insert Table 1 about here

The mean Mathematics Achievement Test score of 224 students was 16.8 out of a maximum of 40 and the standard deviation was 5.56. The highest score was 38 and the lowest score was 5. The internal consistency of the test was judged to be adequate; the KR-20 reliability coefficient was .77. The test scores correlated significantly with students' Algebra 30 grades (r = .60, one-tailed p < .001).

Four multivariate analyses of variance were performed on the data of 191 students; sex and intention to pursue math-related program were the two independent variables and mathematics achievement, math self-efficacy, math attitude, and Math Survey I were the four

dependent variables, respectively. Chi-square tests and loglinear analyses were used to analyze categorical variables in the questionnaire (Math Survey II).

Results

Hypothesis One: Effects of Intention to Pursue Math-related Post-secondary Academic Programs

Mathematics Achievement

Table 2 shows the means and standard deviations of the test scores. As expected, those who intended to pursue math-related programs performed better than those who intended not to [Multivariate test: $F(16,544) = 2.28$, $p < .01$].

Univariate F-tests showed that the effect was significant on three test component scores: identification of concepts [$F(4,181) = 3.44$, $p < .01$], comprehension of concepts [$F(4,181) = 3.07$, $p < .05$], and application/problem solving [$F(4,181) = 5.69$, $p < .001$]. Pairwise comparisons using Student-Newman-Keuls tests showed that those who intended to pursue math-related programs had significantly higher scores on concept comprehension and on application/problem solving ($p < .05$) than those who intended not to (see Table 2).

Insert Table 2 about here

Learning and Instructional Processes

Courses taken or to be taken. As expected, the number of mathematics courses taken or to be taken was significantly correlated with intention to pursue math-related program (r = -.41, N = 225, one-tailed p < .001). Those students who had taken or who intended to take more mathematics courses tended to indicate an intention to pursue math-related post-secondary academic programs.

Past performance is important too. Those who did well in Algebra 20 [χ^2(12, N =223) = 30.79, p < .01] and in school in general [χ^2(8, N =222) = 16.43, p < .05] had a more definite intention in pursuing math-related post-secondary programs. Those who found Algebra 20 examination difficult [χ^2(8, N = 221) = 34.41, p < .001] tended to indicate that they did not intend to pursue math-related programs.

Teaching method. Intention to pursue math-related post-secondary program was associated with "Teachers using guided discussion" [χ^2(4, N = 224) = 17.40, p <

.01] and "Teachers relating math to everyday life" [$\chi^2(8, N = 224) = 18.28, p < .05$]. Students whose teachers rarely or never related math to everyday life tended not to intend to pursue math-related post-secondary programs.

Internal motivational beliefs

As shown in Table 3, those who intended to pursue math-related programs had significantly greater self-efficacy expectations in math than those who intended not to pursue math-related programs [Multivariate test: $F(12,474) = 3.94, p < .001$]. Univariate F-tests showed that the effect was significant on daily math tasks [$F(4,181) = 5.86, p < .001$], on math-related high school courses [$F(4,181) = 6.56, p < .001$], and on math academic problems [$F(4,181) = 7.26, p < .001$].

Insert Table 3 about here

In general, those who intended to pursue math-related programs had significantly more positive attitude toward math [Multivariate test: $F(24,615) = 4.74, p < .001$]. As shown in Table 4, those who

intended to pursue math-related programs had less anxiety toward math [$F(4,181) = 6.59$, $p < .001$], enjoyed math more often [$F(4,181) = 21.84$, $p < .001$], had higher motivation in math [$F(4,181) = 8.35$, $p < .001$], perceived greater math ability in themselves [$F(4,181) = 12.64$, $p < .001$], and believed math to be a useful subject [$F(4,181) = 11.30$, $p < .001$].

Insert Table 4 about here

Consistent with the above findings, they indicated a more positive attitude towards math on Ethington and Wolfle's (1984) scale [$F(4,181) = 15.71$, $p < .001$]. They had more internal locus of control [$F(4,181) = 3.64$, $p < .01$] (see Table 5) and spent more time on math homework [$F(4,214) = 3.94$, $p < .01$] than those who intended not to pursue math-related programs.

Insert Table 5 about here

Hypothesis Two: Sex Effects

Mathematics Achievement

As expected, males (mean score 18.36) outperformed

females (mean 15.75) significantly [Multivariate test: $F(4,178) = 4.26$, $p < .01$]. A significantly larger percentage of males (18.7%) than of females (6.1%) had a score of 24-40. Females were overrepresented in the lowest score category (1-11) (females 20.4% versus males 9.3%) [$X^2(5, N = 205) = 11.21$, $p < .05$].

Univariate F-tests showed that males excelled in two of the four components. First, on the concept identification component, the mean score of males was 3.61 and that of females was 3.22 [$F(1,181) = 4.71$, $p < .05$]. Second, on the application and problem solving component, the mean score of males was 6.59 and that of females was 5.10 [$F(1,181) = 14.11$, $p < .001$].

The differences in achievement were still significant even when the effect of number of courses was partialled out [Multivariate test: $F(4,186) = 5.88$, $p < .001$; Univariate F-tests: identification [$F(1,189) = 5.02$, $p < .05$]; application [$F(1,189) = 20.36$, $p < .001$]. The differences in achievement were also significant when intention to pursue math-related program was controlled for [Multivariate test: $F(4,186) = 5.88$, $p < .001$; Univariate tests: identifaction:

$F(1,189) = 5.02$, $p < .05$; application: $F(1,189) = 20.36$, $p < .001$].

Learning and Instructional Processes

Courses taken or to be taken. Males and females did not differ significantly in the number of courses taken or to be taken [$t(223) = 1.61$, two-tailed $p = .109$].

However, sex was associated with "Intention to take Geo-trig 30" (a grade 12 course) [$\chi^2(2, N = 224) = 6.89$, $p < .05$] and "Taken Algebra 30 if not required" [$\chi^2(2) = 7.03$, $p < .05$]. More females tended to say "no" or were "not sure" if they would take Geo-trig 30. It appears that more males said "no" to taking Algebra 30 if the course was not required for post-secondary education, but more females were "not sure".

Learning habits and styles. Females spent more time on math homework than males (mean 4.70 versus 3.29 hours per week) [$F(1,214) = 6.62$, $p < .05$] and spent less time watching television (mean 11.06 versus 15.12 hours per week) [$F(1,214) = 9.02$, $p < .01$]. More females than males tended to get help in doing math homework (female 57.4% versus male 42.7%) [$\chi^2(1, N = 225) = 4.84$, $p < .05$] and to get help from friends

(females 49.1% versus males 29.9%) [$\chi^2(1, N = 225) = 8.66, p < .01$].

Internal motivational beliefs

Males had significantly higher mathematics efficacy expectations than females [Multivariate test: $F(3,179) = 5.92, p < .001$]. Univariate F-tests showed that males were more confident than females in performing daily math tasks [males: mean 119.32 (7.02 per item) versus females: mean 108.89 (6.41 per item] [$F(1,181) = 5.76, p < .05$] and in performing well in math-related high school courses [males: mean 90.95 (6.50 per item) versus females: mean = 77.74 (5.55 per item] [$F(1,181) = 8.90, p < .01$].

These effects were significant even when math achievement was controlled for [Multivariate test: $F(3,187) = 7.58, p < .001$; Univariate tests: daily task $F(1,189) = 10.45, p < .001$; math courses $F(1,189) = 16.06, p < .001$] or when the number of courses was used as a covariate [Multivariate test: $F(3,187) = 7.58, p < .001$; Univariate tests: daily task $F(1,189) = 10.45, p < .001$; math-related courses $F(1,189) = 16.06, p < .001$].

Males also had a significantly higher self-esteem than females [males: mean = 12.48 (3.12 per item) versus

females: mean = 11.66 (2.92 per item)] [$F(1,181) = 7.84$, $p < .01$]. The differences were significant even when math achievement was used as a covariate [$F(1,189) = 7.23$, $p < .01$]. Males had more positive perception of math ability than females when the effect of math achievement was partialled out [$F(1,189) = 5.09$, $p < .05$].

Sex Stereotypical Bias

Consistent with previous research findings, there was a signicant multivariate sex effect on sex stereotypical bias [$F(2,209) = 27.49$, $p < .001$]. The mean score for two items in Math Survey II was 8.20 for females and 6.60 for males, indicating that females had less sex stereotypical bias. Females tended to disagree that "some fields of study or work are more suited for men than for women and vice versa" [$F(1,210) = 30.16$, $p < .001$] and that "the study of math is a more appropriate area for men than for women" [$F(1,210) = 37.73$, $p < .001$]. Similar results were obtained when an ANOVA was performed on the sex-role orientation scores in Ethington and Wolfle's scale [$F(1,181) = 35.16$, $p < .001$]; females had fewer sex stereotypical biases (mean = 16.49) than males (means = 14.16).

In addition, female students perceived their

parents' to be less sex stereotyped than did male students [$F(3,212) = 3.59$, $p < .05$]. The mean score of three items in Math Survey II was 12.81 for females and 12.33 for males, indicating that female students perceived their parents to have less sex stereotypical bias. Female students believed that their parents and family members disagreed more strongly to "some fields of study or work are more appropriate for women than for men and vice versa" [$F(1,214) = 6.07$, $p < .05$], and to "you should consider certain areas of study/work because you are male/female" [$F(1,214) = 6.05$, $p < .05$].

Interaction of Hypotheses One and Two:
Intention to Pursue Math-related Program and Sex

That males and females did not differ significantly in their intention to pursue math-related program is unexpected [$\chi^2(4, N = 224) = 3.56$, $p > .05$]. Neither were there any significant interaction effects on mathematics achievement, self-efficacy, personal, or motivational variables. Loglinear analyses of the categorical variables (learning and instructional processes) showed no significant interaction effects either.

Discussion

This study has shown, not surprisingly, that students with varying intention to pursue math-related post-secondary academic programs do differ in their math achievement scores and a number of internal motivational and learning process variables. Although males and females differ in some of these variables, the patterns of relationship between intention to pursue math-related programs and math achievement, internal motivational and learning process variables do not differ significantly between males and females. In other words, any observed sex-related differences are overwhelmed by the differences between those intending to pursue math further and those not intending.

The male students in this study had higher achievement scores than the female students, especially in concept identification and application/problem solving components. The best males performed at higher levels than the best females. These findings are consistent with the results of previous research (Benhow & Stanley, 1980; 1981; National Assessment of Educational Progress, 1988; Randhawa, 1988; Randhawa & Hunt, 1987). Interestingly, those students who intended

to pursue math-related post-secondary education also achieved higher than those who intended not to on thes two components and on concept comprehension.

It is clear that performance on these components, involving logical reasoning and higher mental processe is critical to sex differences. This performance alsc discriminates groups with varying intention to pursue mathematics.

Males outperform females even when the number of courses or intention to pursue math-related progams ha been partialled out. These findings do not support Fennema and Sherman's differential course-taking hypothesis. Motivational and social contexts might be more important or precede these choices themselves.

Male and female students in this study did not differ in math enjoyment, but females spent more time math homework than males despite their generally lower achievement. This finding is consistent with Randhawa Beamer, and Yuzik's (1989) results for first-year university students and suggests that males and female may use different strategies in solving math problems and getting the work done and benefitting from it.

Our findings support the interrelationships among

math achievement, participation, and academic choice. The more math courses taken or to be taken and the higher the past achievement in math, the greater interest in pursuing math. No significant sex differences in the number of courses were found, although females seemed to be more unsure of their intentions to take non-required math courses than were males.

For both males and females, those intending to pursue math-related academic program had more positive attitudes, higher self-efficacy expectations, and more internal locus of control than those intending not to. They perceived math as a useful subject in everyday life, enjoyed math frequently, had less math anxiety, had higher math motivation, perceived greater math ability in themselves, and spent more time on math homework. These results are consistent with the Autonomous Learning Behavior theory (Fennema & Peterson, 1983), and the findings of Ethington and Wolfle (1988), Fennema and Sherman (1977), Betz and Hackett (1983), and Lantz and Smith (1981), and predictions from the Bandura's self-efficacy theory (1977, 1982).

Consistent with previous findings (Lantz & Smith,

1981; National Assessment of Educational Progress, 1989) female students had less sex stereotypical bias than male students. Females agreed more strongly than males that they could do anything including mathematics as well as males. Yet they had lower self-esteem and lower math self-efficacy. One possible explanation is that the questions on sex stereotype refer to general attitude about women's ability, i.e., other women's. On the other hand, questions about self-esteem and math self-efficacy are personal. When assessments about themselves as individuals are involved, their evaluations are guided by their own experiences. The under-representation of appropriate female role models may have lowered their confidence in entering a male-dominated field. Sex-role orientation per se did not have any significant effects on students' attitude or achievement.

More females than males received help in doing math homework and the help often came from friends. This reflects the general social norm for females to appear dependent, to seek help from others, and to be cooperative and for males to be independent (Maccoby & Jacklin, 1974) and competitive (Greenglass, 1982).

That intention to pursue math-related post-secondary program is related to teachers using guided discussion and teachers relating math to everyday life has important implications for math instruction. Increasing the relevance of high school math courses and ensuring that students learn how to think about everyday problems are necessary (Linn & Hyde, 1989; Paulos, 1988). So is active participation in class discussions important. A second study is currently in process to assess grade 12 student' competence in solving "real-life" math problems.

Practical Implications

The findings of this study suggest that, for both male and female students, instructional approaches that increase students motivation and enjoyment in math are most likely to increase participation and achievement in mathematics. In our curriculum, more emphasis should be put on the usefulness and relevance of math to everyday life. Starting in early grades, mathematics should be taught as a functional tool to deal with situations children and people face. Properly motivated students, no matter what subject, learn the content regardless of its difficulty better. Utility of the mathematical

concept in introducing it should be dealt with first during the instructional process.

References

Backman, M. E. (1972). Patterns of mental abilities: Ethnic, socioeconomic, and sex differences. American Educational Research Journal, 9, 1-12.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. Psychological Review, 84, 191-215.

Bandura, A. (1982). Self-efficacy mechanism in human agency. American Psychologist, 37, 122-147.

Begle, E. G., & Wilson, J. W. (1970). Evaluation of mathematics programs. In E. G. Begle, & H. G. Richey (Eds.). Mathematics education (Ch. 10). Chicage, IL: The National Society for the Study of Education.

Benbow, C. P., & Stanley, J. C. (1980). Sex differences in mathematical ability: Fact or fiction. Science, 210, 1262-1264.

Benbow, C. P., & Stanley, J. C. (1981). Mathematical ability: Is sex a factor? Science, 212, 118-121.

Benbow, C. P., & Stanley, J. C. (1983). Sex differences in mathematical reasoning ability: More facts. Science, 222, 1029-1031.

Betz, N. E., & Hackett, G. (1983). The relationship of mathematics self-efficacy expectations to the selection of science based college majors. Journal of Vocational Behavior, 23, 329-345.

Bloom, B. S. (Ed.) (1956). Taxonomy of educational objectives: The classification of educational goals. New York: David McKay Inc.

Dossey, J. A., Mullis, I. V. S., Lindquist, M. M., & Chambers, D. L. (1988). The mathematics report card. Are you measuring up? Trends and achievement based on the 1986 national assessment. Princeton, N.J.: Educational Testing Service.

Dweck, C. (1986). Motivational processes affecting learning. American Psychologist, 41, 1040-1048.

Dweck, C. S., Davidson, W., Nelson, S., & Enna, B. (1978). Sex differences in learned helplessness: I. The contingencies of evaluative feedback in the classroom and II. An experimental analysis. Developmental Psychology, 14, 268-276.

Eccles, J. (1984). Sex differences in achievement patterns. Nebraska Symposium on Motivation, 32, 92-132.

Ernest, J. (1976). Mathematics and sex. American Mathematical Monthly, 83, 595-612.

Ethington, C. A., & Wolfe, L. M. (1988). Women's selection of quantitative undergraduate fields of study: Direct and indirect influences. American Educational Research Journal, 25, 157-175.

Fennema, E. (1974). Mathematics learning and the sexes: A review. Journal of Research in Mathematics Education, 5, 126-139.

Fennema, E. (1983). Research on relationships of spatial visualization and confidence to male/female mathematics achievement in grade 6-8. (Report No. NSF/SED 83004). Madison, WI: Wisconsin University. (ERIC Document Reproduction Service No. ED 232853)

Fennema, E., & Peterson, P. L. (1985). Autonomous learning behavior: A possible explanation of sex-related differences in mathematics. Educational Studies in Mathematics, 16, 309-311.

Fennema, E., & Sherman, J. (1977). Sex-related differences in mathematics achievement, spatial visualization, and sociocultural factors. American Educational Research Journal, 14, 51-71.

Fox, L. H., Brody, L., & Tobin, D. (Eds.) (1980). Women and the mathematics mystique. Baltimore, MD: John Hopkins University Press.

Greenglass, E. S. (1982). A world of difference -- Gender roles in perspective. Toronto: John Wiley.

Hackett, G., & Betz, N. E. (1981). A self-efficacy approach to the career development of women. Journal of Vocational Behavior, 18, 326-329.

International Assessment of Educational Progress (1988). A World of differences -- An international assessment of mathematics and science. Author.

Lantz, A. P., & Smith, G. P. (1981). Factors influencing the choice of non-required mathematics courses. Journal of Educational Psychology, 73, 825-837.

Linn, M. C., & Hyde, J. S. (1989). Gender, mathematics, and science. Educational Researcher, 18, 17-21, 22-27.

Lockheed, M. E., & Klein, S. S. (1985). Sex equity in classroom organization and climate. In S. S. Klein (Ed.) Handbook for achieving sex equity through education. Baltimore, MD: John Hopkins University.

Maccoby, E. E., & Jacklin, C. N. (1974). The psychology of sex differences. Stanford, CA: Stanford University Press.

Minnesota Research and Evaluation Project. (1972). Mathematics attitude inventory. Minneapolis, MN: University of Minnesota.

National Assessment of Educational Progress (1988). The national mathematics assessment. Princeton, NJ: Author.

Paulos, J. A. (1988). Innumeracy: Mathematical illiteracy and its consequences. New York: Vintage Books.

Randhawa, B. S. (1988). Basic skills and macro- and micro-analysis of mathematics achievement of grade ten students as a function of gender and locale. British Educational Research Journal, 14, 141-148.

Randhawa, B. S., Beamer, J. E. & Yuzik, S. (1989). Sex differences in mathematics performance and perceptions of university students. A paper presented at the Canadian Psychological Association Convention in Halifax, June, 1989.

Randhawa, B. S., & Hunt, D. (1987). Sex and rural-urban differences in standardized achievement scores and mathematics subskills. Canadian Journal of Education, 121, 137-151.

Sells, L. W. (1980). The mathematics filter and the education of women and minorities. In L. H. Fox, L. Brody, & D. Tobin (Eds.) Women and the mathematical mystique (pp. 66-75). Baltimore: John Hopkins University Press.

Sherman, J., & Fennema, E. (1977). The study of mathematics by high school girls and boys: Related variables. American Educational Research Journal, 14, 159-168.

Stake, J. E., & Katz, J. F. (1982). Teacher-pupil relationship in the elementary school classroom. American Educational Research Journal, 19, 465-471.

Vetter, B. (1981). Women in science and engineering: Trends in participation. Science, 214, 1313-1321.

Table 1.

Reliability of Instruments

Subscale	No. of Items	Alpha
Mathematics Survey I		
Self-conecpt (esteem)	4	.71
Locus of control	3	.42
Attitude toward math	6	.86
Sex-role orientation	5	.70
Family orientation	3	.36
Whole scale	21[a]	.77
Mathematics Attitude Inventory		
Perception of math teacher	8	.81
Anxiety toward math	6	.80
Value of math in society	7	.75
Self-concept in math	6	.87
Enjoyment in math	7	.88
Motivation in math	4	.67
Whole scale	48[b]	.81

Mathematics Self-efficacy Scale

Daily math tasks	17[c]	.88
Math-related courses	14	.92
Academic math problems	18	.89
Whole scale	49	.88

Note.

[a] Two items with low item-total correlations were deleted. [b] Ten items were not included in any of the subscales. [c] One obsolete item was deleted.

Table 2.

Means and Standard Deviations of Mathematics Achievement Scores by Intention to Pursue Math-related Post-secondary Program

Group	Intention to Pursue Program				
	Definitely Yes	Most Likely Yes	Maybe	Most Likely No	Definitely No
N	22	49	46	45	29
	Concept identification (7 items)				
M	3.77	3.71[b]	3.02[a]	3.60[b]	3.00
S.D.	1.23	1.35	1.22	1.07	0.85
	Computation (12 items)				
M	4.91	5.82	4.91	4.80	4.41
S.D.	2.39	2.50	2.39	2.15	1.97
	Concept Comprehension (7 items)				
M	2.96	3.22[b]	2.65	2.76	2.10[a]
S.D.	1.79	1.50	1.12	1.35	1.21
	Application/Problem solving (14 items)				
M	6.46[b]	7.06[c]	5.65[d]	5.31[d]	4.62[ad]
S.D.	2.81	2.44	2.11	2.01	2.04
	Total (40 items)				
M	18.09	19.82[a]	16.24[b]	16.47[b]	14.14[b]
S.D.	7.15	6.13	5.23	4.78	4.29

Note.

The means indicated by [a] and [b], and [c] and [d] are significantly different (Student-Newman-Keuls test $p < .05$).

Table 3.

Means and Standard Deviations of Mathematics Self-efficacy Scores Per Item by Intention to Pursue Math-related Post-secondary Program

	Intention to Pursue Program				
Group	Definitely Yes	Most Likely Yes	Maybe	Most Likely No	Definitely No
N	22	49	46	45	29
	Daily tasks (17 items)				
M	7.30^{c}	7.29^{a}	6.28^{bd}	6.56^{b}	6.29^{bd}
S.D.	1.00	0.97	1.60	1.16	1.49
	Math-related Courses (14 items)				
M	6.89^{bd}	6.68^{bdf}	6.00^{be}	5.63^{c}	5.03^{a}
S.D.	1.21	1.33	1.79	1.60	1.85
	Academic problems (18 items)				
M	7.69^{b}	7.82^{bc}	7.25^{bd}	6.99^{d}	6.53^{a}
S.D.	0.66	0.83	1.35	1.21	1.52
	Total (39 items)				
M	7.33^{bdf}	7.31^{bdf}	6.56^{be}	6.45^{bc}	6.02^{a}
S.D.	0.79	0.89	1.43	1.09	1.42

Note. Scores ranged from 1 (No confidence at all) to 10 (Complete confidence); higher scores indicated greater self-efficacy than did lower scores.
The means indicated by [a] and [b], [c] and [d], and [e] and [f] are significantly different (Student-Newman-Keuls test $p < .05$).

Table 4.

Means and Standard Deviations of Mathematics Attitude Inventory Scores (per Item) by Intention to Pursue Math-related Post-secondary Program

Group	Intention to Pursue Program				
	Definitely Yes	Most Likely Yes	Maybe	Most Likely No	Definitely No
N	22	49	46	45	29
	Perception of teacher (8 items)				
M	3.18	3.06	2.85	2.95	2.86
S.D.	0.57	0.45	0.52	0.55	0.52
	Math anxiety (6 items)				
M	3.21^{b}	3.29^{bd}	3.23^{b}	3.04^{bc}	2.79^{a}
S.D.	0.65	0.40	0.38	0.44	0.45
	Math enjoyment (7 items)				
M	2.89^{bd}	2.99^{bdf}	2.67^{bde}	2.37^{bc}	1.94^{a}
S.D.	0.59	0.43	0.54	0.56	0.48
	Value in society (7 items)				
M	3.33^{bdf}	3.29^{bdf}	2.99^{bc}	3.01^{be}	2.71^{a}
S.D.	0.39	0.37	0.48	0.34	0.50
	Math motivation (4 items)				
M	2.03^{bd}	2.08^{bd}	1.92^{bd}	1.71^{bc}	1.50^{a}
S.D.	0.45	0.47	0.59	0.44	0.37

	Perception of math ability (6 items)				
M	2.99^{b}	3.19^{bdf}	2.87^{be}	2.75^{bc}	2.32^{a}
S.D.	0.51	0.48	0.56	0.53	0.55
	Total (38 items)				
M	3.01^{bdf}	3.04^{bdf}	2.81^{be}	2.71^{bc}	2.42^{a}
S.D.	0.36	0.30	0.34	0.33	0.36

Note.

Scores ranged from 1 to 4; higher scores indicated a more positive attitude than did lower scores.

The means indicated by ^{a} and ^{b}, ^{c} and ^{d}, and ^{e} and ^{f} are significantly different (Student-Newman-Keuls test $p < .05$).

Table 5.

Means and Standard Deviations of Ethington and Wolfle's Scale Scores (per Item) by Intention to Pursue Math-related Post-secondary Program

	Intention to Pursue Program				
Group	Definitely Yes	Most Likely Yes	Maybe	Most Likely No	Definitely No
N	22	49	46	45	29
	Locus of control (3 items)				
M	3.50[b]	3.50[b]	3.32	3.37	3.16[a]
S.D.	0.37	0.43	0.37	0.46	0.36
	Sex-role orientation (5 items)				
M	3.07	3.16	3.05	3.03	2.99
S.D.	0.66	0.49	0.56	0.53	0.49
	Family orientation (3 items)				
M	3.27	3.24	3.12	3.27	3.21
S.D.	0.42	0.55	0.43	0.47	0.56
	Self-esteem (4 items)				
M	3.16	3.17	2.90	3.01	2.87
S.D.	0.43	0.49	0.52	0.52	0.64
	Math attitude (6 items)				
M	3.25[bdf]	3.21[bdf]	2.89[be]	2.70[bc]	2.28[a]
S.D.	0.64	0.50	0.51	0.52	0.69

Note.

Scores ranged from 1 to 4; higher scores indicated greater internal locus of control, less sex stereotyping, pro-family orientation, positive attitude, or positive self-esteem.

The means indicated by [a] and [b], [c] and [d], and [e] and [f] are significantly different (Student-Newman-Keuls test $p < .05$).